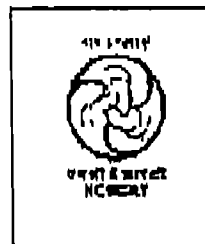


GENDER DIFFERENCE IN MATHEMATICAL ABILITIES

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PREFACE

A society cannot progress materialistically or spiritually unless its women are educated and enlightened even if its men may be highly educated. If we refer the post-independence situation in education from the point of view of what has been achieved for education of women, we find that the record is impressive but uneven. The gap between the level of literacy among men and women is a glaring evidence. Also the number of women pursuing research in mathematics and the female mathematicians are not significant in comparison with their counter parts. Mathematics plays a critical role in Science and Technology, aesthetics and has occupied a unique position in development of a society. Mathematics foundation skills are critical for success in today's high performance work place

Researches in other countries indicated that males consistently outperform females in the solving of mathematical word problems and in geometry. Also they indicated that male co-opt the spatial systems in problem-solving situations more readily than females. However there are no systematic studies to reveal the sex differences in mathematical abilities in the Indian situation. Therefore, one has to pursue a systematic detailed study in the Indian context to explore the possible areas of sex differences in mathematical abilities with respect to speed, problem-solving, creativity, cognitive, affective and psychomotor domains, biological factors (chemistry of brain, physical weakness, hormones etc.), curriculum bias, attitudes, language etc. Here we

made an attempt to study sex differences regarding the following mathematical abilities: i) arithmetical ability ii) abstract thinking iii) logical thinking iv) symbolizing concepts v) precision vi) discovery approach vii) mathematical modeling viii) application skills ix) generalisation skills and x) attitudes.

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Gender Differences and Mathematical Abilities

Introduction :

It is an indisputable fact that women's education plays a pivotal role in the reformation and progress of a society. A society cannot be enlightened nor can it progress materialistically or spiritually unless its women are educated and enlightened even if its men may be highly educated. At the end of five decades of planned efforts to gear education towards development and to bring about equality of opportunity in and through education in India, we find the achievement of both objectives has been impressive in parts, but nevertheless inadequate and uneven.

If we review the post-independence situation in education from the point of view of what has been achieved for the education of women, we find that the record is impressive but uneven. The rate of increase in the enrolment of girls at school level has been high. At the same time, gender inequality in education remains highly pronounced: the gap between the level of literacy among men and women is the simplest evidence. Another indicator of gender inequality is the relatively poorer enrolment of girls in professional courses at the university level. Research reveals that several factors are responsible for these inequalities. They range from parental reluctance to send their daughters over long distances to school and parental unwillingness to spend on the education of their daughters. Daughters are being engaged in housework to take care of younger siblings, utilization of their services in fetching water or collecting fuel and fodder (especially in rural areas). To overcome these obstacles several measures have been set

into operation by Government of India. For instance, cost free education, stipends, provision of women teachers, facilities for schooling of girls, distance education programmes etc.

Mathematics is a Necessary Subject

Kothari Commission (1964-66) has pointed out :

" We cannot overstress the importance of mathematics in relation to science, education and research. This has always been so, but at no time has the significance of mathematics been greater than today..... it is important that deliberate effort is made to place India on the 'World map of mathematics' within the next two decades or so".

The value of mathematics as one of Russel's "great things" something necessary for life as "art" and not just fact. The value of mathematics as Polking Horne's "abstract key which turns the lock of physical universe"

Mathematics has played a decisive role in building up our civilization and therefore, it has become essential for the existence and progress of modern world. In today's world we have to be exact in our expression and so we make larger use of quantitative methods. Mathematics has not only been useful in its own right but it has also enriched this world by helping in development of other fields of knowledge.

Mathematics exhibits the power to think consistently and logically. It helps in our quest for knowledge, truth and beauty, desire to interpret and control our environment. Our culture is on the move through mathematization. Consequently, women are increasingly interested in mathematics. Yet the number of women pursuing research in mathematics and the female mathematicians are not significant in comparison with their counter parts.

Significant research was done by Eccles [3], Wise [12], Stanley [11] and many others regarding the gender disparity. The focus of research was on a) attitudes such as the perception of mathematics as a male domain, b) support and encouragement from significant other factors, and c) access to role models.

Mathematics foundation skills are critical for success in today's high-performance work place. Developing mathematics-learning skills is an essential tool to help mathematics anxious young people build those skills.

Many researchers like Royer, Geary[5, 6] have attempted to study the nature and the source of the sex difference in mathematics abilities. Geary [6] reviewed the research on sex differences in mathematical abilities and pointed out the following:

- i) The sex difference in mathematical abilities is largely due to a sex difference, favouring boys and men, especially in the speed of arithmetic-fact retrieval.
- ii) Individual differences in skill at solving multistep arithmetical word problems were related to individual differences in working memory capacity and to the speed of arithmetic-fact retrieval and carrying out arithmetic operations.
- iii) It is not clear how the automaticity of arithmetical processes would improve performance in mathematical terms that do not require arithmetic.
- iv) The magnitude of the sex difference in mathematical abilities varies with the mathematical content of the tests and with the age and overall ability of the individuals assessed. The

advantage of being male is most evident in high-ability samples and for the solving of word problems and items that require complex spatial competencies.

- v) The social sex differences might contribute to the sex difference in mathematics achievement.
- vi) The cognitive sex differences are related to mathematical ability, specifically math-fact retrieval and spatial cognition.
- vii) The relations among biological factors (e.g. sex hormones), experience, and sex differences in brain, cognition, and social behaviour are very complex.
- viii) It is observed in some species that the brains of females and males sometimes respond (e.g. in terms of growth of dendrites) differently to the same experience, apparently through the action of sex hormones.
- ix) The sex differences in mathematical abilities is likely to be experience-based and that any such sex difference in much-related experiences does not have a biological basis in performance. In other words, it cannot be assumed that the different experiences of boys and girls and men and women are driven only by cultural factors (e.g. gender roles) and even with the same experiences it cannot be assumed that cognitive and brain developments of boys and girls will be the same.
- x) The sex difference in vocational interests is especially striking among mathematically-gifted youths. When they are in their 20s, for every mathematically gifted woman who is working towards or who aspires to earn an advanced degree in

mathematics, engineering, or the physical sciences, there are eight equally talented men.

- xi) For the gifted individuals, the sex difference in the pursuit of an advanced education in mathematics-intensive areas cannot simply be attributed to cognitive factors.
- xii) People who enter mathematics-intensive fields tend to have a low need for people contact.
- xiii) Mathematically gifted men, who enter the fields like theoretical and investigative activities, do indeed show the same pattern of occupational and social interests. Mathematically gifted women, in contrast, "are more socially and esthetically oriented and have interests that are more evenly divided among investigative, social, and artistic pursuits". In short, many mathematically gifted women may not choose to enter math-intensive fields because they have broader social and occupational interests than their equally gifted male peers and therefore, more frequently pursue occupations outside of these math-intensive areas.
- xiv) It appears that gifted women are more interested in careers that involve living things (e.g. biology and medicine) as opposed to inorganic things (e.g. physics and engineering).
- xv) Sexual and natural selection are also potentially related to the cognitive sex differences that contribute to the sex difference in mathematical abilities.
- xvi) It is not clear how a male advantage in speed of math-fact retrieval could contribute to the sex difference, favouring boys and men, on mathematical tasks that do not require arithmetic

(e.g. visualizing geometric shapes).

- xvii) Sexual selection can, however, indirectly influence sex differences in mathematical abilities, to the extent that the cognitive and brain systems that support mathematical cognition have been shaped by evolution.
- xviii) The cognitive and brain systems that have evolved to enable movement in and the representation of three-dimensional space are more highly elaborated in boys and men than in girls and women.
- xix) The effect of the sex difference in navigational competencies is that boys and men have an advantage in mathematical areas that require an understanding of geometry and involve the use of spatial representations of mathematical information, including the use of spatial representations to solve complex word problems.

Elizabeth Fennema and Sherman [10] observed that males were more confident about learning mathematics than were females. Also differences between males and females in spatial skills, particularly spatial visualization or the ability to visualize movements of geometric figures in one's mind, have long been reported.

Gordon Stobart [7] and others also observed better results for girls in subjects other than mathematics and some sciences.

In the Indian context, we have no evidence to prove the validity of the observations. Very few researchers attempted to compare merely the achievement (in mathematics) of boys and girls at different stages. To mention these, Rastogi [9] observed that there was no sex difference in

mathematics achievement. Base line studies indicate that the achievement of boys was comparatively higher than that of girls. Kartik Chandra Mandal [8] observed that to some extent girls in VIII class were better than the boys in respect of creativity in mathematics. Also he observed that boys in general were better than girls regarding fluency, flexibility, originality of creativity aspects of mathematics. Basavayya [1] pointed out that the perception of mathematics among boys was better than that of the girls.

Of course there were a few studies about the measurement of gender differences related to general abilities. However in all, there were no systematic studies worth mentioning to reveal the sex differences in mathematical abilities in the Indian situation. Therefore, one has to pursue a systematic detailed study in the Indian context to explore the possible areas of sex differences in mathematical abilities with respect to speed, problem solving, creativity, cognitive, affective and psychomotor domains, biological factors - chemistry of brain, physical weakness, hormones etc. curriculum bias, attitudes, language etc. with the following questions in mind.

Are males and females fundamentally different with respect to learning?

Are males and females fundamentally the same, with the exception of their biological differences, and are these differences irrelevant with respect to mathematics?

Here an attempt has been made to conduct a study covering the following mathematical abilities: i) arithmetical ability ii) abstract thinking iii) logical thinking iv) symbolizing concepts v) precision vi) discovery approach vii) mathematical modeling viii) application skills ix) generalization skills and x) attitudes.

Objectives:

- i) To identify the areas in which sex difference exists regarding the mathematical ability.
- ii) To find out the extent of these differences that affect the overall development of the careers of the individuals.
- iii) To suggest the educators and parents the way to reduce the gender gap, if any.

Methodology :

Two types of tools have been developed – one to measure the mathematical abilities and the other to identify the factors responsible for gender differences in mathematics. In the first category specially prepared tests were used to measure the mathematical abilities of boys and girls . In the second category three types of opinionnaires (Appendix-2) were prepared and administered to the selected number of students and Mathematics teachers/ teacher educators. The opinionnaires were mainly in the form of check lists and with few open-ended questions . Some interviews were also conducted. The selection of students and teachers was done using stratified random sampling procedure.

Analysis

Language and Mathematics are two inevitable basic academic components of any school curriculum. Language comes to a child naturally while it is not the same for mathematics. Acquiring of mathematical knowledge requires deliberate efforts by students involving special attributes and capabilities from their part. Learner may have to develop certain attributes and capabilities to have sound knowledge of mathematics through study and

training. Here an attempt has been made to enumerate some of these attributes.

Since arithmetic is the subject on which the whole of mathematics rests, learning of mathematics starts with numbers and basic arithmetic operations. Therefore, it is essential for a student to develop arithmetical ability that enables him or her to compute and deal with numbers effectively. Mathematics by its very nature is an abstract subject. In the beginning although students are taught mathematics through concrete objects, after certain stage there is bound to be a shift from concrete level of thinking to abstract level. Hence, thinking at an abstract level forms another capability that a learner of mathematics should possess.

The hallmark of mathematics lies in its two valued logic viz., true or false. That is where the precision or uncompromising nature of mathematics is revealed. Infact it is this precision of mathematics that makes it difficult for the learners. The most challenging area of mathematics is the problem solving or so called mathematical modeling as this technique quite often is inter disciplinary in nature.

Keeping the above facts of mathematics in our mind, some of the capabilities the learner of mathematics may have to possess were listed below and enumerated.

- i. Arithmetical Ability: Earlier studies reveal that girls were comparatively better regarding this ability as can be seen from table 1 , although statistically insignificant. The arithmetic ability of girls appeared better except in class 8 and class 11. Generally boys were more concerned to score high marks in classes 11 and 12 to get admission into technical courses. This

could be one of the reasons for the better performance of boys in arithmetical skills at 11th and 12th classes.

- ii. Abstract Thinking: In general boys were good in abstract thinking except in class 9 when there was a temporary decline in comparison to girls. It is because girls would be more matured than boys when they reach class 9.
- iii. Logical Thinking: Unlike abstract thinking, girls were good in logical thinking at all levels except in class 8.
- iv. Symbolising Concepts: Table 1 indicated that in class 7 and 8 boys were better than girls in symbolising the mathematical concepts.
- v. Precision: This ability was measured from class 7 onwards. It was observed from table 1 that there was no difference between boys and girls at school level although girls were better at college level. This might be due to the better standard of female students at the time of admissions to the B.Sc Ed course.
- vi. Discovery Approach: General opinion was that boys prefer discovery approach of learning. But it was observed that there was no difference between boys and girls regarding this concept except in class 5. This might be due to their experimental nature of mind at that stage.
- vii. Mathematical Modeling: It was thought of measuring this ability from class 8 onwards as the students of this age try to solve problems in different fields by expressing them in mathematical terms. Female students have some superiority in mathematical modeling at higher level (college level) even though there was no significant difference at lower levels.

- viii. **Application Skills:** The application and use of mathematics will be noticed only when students use mathematical knowledge to solve problems in different disciplines and situations. It was observed that the male and female students have the same mathematical application skills.
- ix. **Generalisation Skills:** Generalisation of known mathematical knowledge / concepts in wider situations is important for mathematical learning. In this study it was observed that boys and girls did not differ much in generalisation skill.
- x. **Attitudes Towards Mathematics:** One can learn different concepts when they are having positive attitude towards that. This is particularly very much true in case of mathematics learning. Therefore, in this study it was attempted to measure the attitudes of males and females towards mathematics at different levels. Information regarding different aspects pertaining to the perception of mathematics was obtained by administering the questionnaire 3.

For visual comparison of the mathematical abilities of males and females were shown in Appendix I.

The responses to the questionnaires pertaining to different aspects were converted into scores by comparing with the responses of experts group. Based on these scores the different items were assigned ranks separately for male and females. Also an overall index for each aspect was computed in case of males and females for comparison purpose. These are shown in tables 2.1 to 2.16 and table 3. Higher value of index indicates better positive attitude towards that aspect.

**TABLE 2.1: RANKS OF MALES AND FEMALES REGARDING THE
PERCEPTION OF MATHEMATICS**

ASPECT	EXPERT	MALES	FEMALES
Mathematics is a study of Numbers.	1	1	1
Mathematics is a study of symbols.	5	4	4
Mathematics is a study of Geometrical figures.	3	2	2
Mathematics is a study of computation	4	5	6
Mathematics is a study of proofs.	2	3	3
Mathematics is a study of Sets.	6	6	5

Correlation between Experts and Males : 0.8857

Correlation between Experts and Females : 0.7714

Correlation between Males and Females : 0.9429

**Table 2.2 : RANKS OF MALES AND FEMALES REGARDING
LIKING OF DIFFERENT BRANCHES OF MATHEMATICS**

<u>Branch</u>	EXPERT	MALES	FEMALES
Algebra	1	2	1
Arithmetic	2.5	3	2.5
Geometry	2.5	1	2.5

Correlation between Experts and Males : 0

Correlation between Experts and Females : 1

Correlation between Males and Females : 0

**Table 2.3 : RANKS OF MALES AND FEMALES REGARDING THEIR
LIKING OF ALGEBRA**

Reason	EXPERTS	MALES	FEMALES
Algebra is more powerful than arithmetic.	1	3	3
Algebra has symbols.	3	2	2
Algebra is more general compared to arithmetic.	2	1	1

Correlation between Experts and Males : -0.5

Correlation between Experts and Females : -0.5

Correlation between Males and Females : 1.0

**Table 2.4 : RANKS OF MALES AND FEMALES REGARDING
DISLIKING OF ALGEBRA**

Reason	EXPERTS	MALES	FEMALES
Algebra has symbols.	3	3	3
Algebra is not meaningful as arithmetic.	2	2	2
Algebra is difficult to understand formulae like $a^m \times a^n = a^{m+n}$, $a^0 = 1$	1	1	1

Correlation between Experts and Males : 1

Correlation between Experts and Females : 1

Correlation between Males and Females : 1

**Table 2.5 : RANKS OF MALES AND FEMALES REGARDING THE
LIKING OF GEOMETRY**

Reason	EXPERTS	MALES	FEMALES
Geometry has beautiful figures and similar figures we can see in different walks of life.	4	4	4
Construction of geometrical figures is an interesting activity.	3	2	1
Many properties can be understood through figures only and no need to remember properties as rules.	2	1	2
The proofs in geometry are easy to understand.	1	3	3

Correlation between Experts and Males : 0.4

Correlation between Experts and Females : 0.2

Correlation between Males and Females : 0.8

**Table 2.6 : RANKS OF MALES AND FEMALES REGARDING
LIKING OF ARITHMETIC**

Reason	EXPERTS	MALES	FEMALES
Arithmetic is useful in daily life.	1	1	1
Arithmetic has no symbols.	3	3	3
Arithmetic helps one to measure Precisely the quantities such as Length, area, volume, etc.	2	2	2

Correlation between Experts and Males : 1

Correlation between Experts and Females : 1

Correlation between Males and Females : 1

**Table 2.7 : RANKS OF MALES AND FEMALES REGARDING
THEIR PERCEPTION ABOUT THE MATHEMATICS
SUBJECT**

ASPECT	MALES	FEMALES
I dislike arithmetic.	5	4.5
I dislike geometry.	3	3
Mathematics should not be made compulsory.	4	4.5
Mathematics helps person to think logically.	1	1
Mathematics is a language of science.	2	2

Correlation between Males and Females = 0.9747

**Table 2.8 : ANSWERS OF MALES AND FEMALES REGARDING
FOLLOWING PROBLEM**

Since $\frac{ab}{ac} = \frac{b}{c}$ then it is natural to expect that $\frac{a+b}{a+c} = \frac{b}{c}$.

Do you agree with this statement

ANSWER	MALES	FEMALES
Nor attempted	13	6
Right answer	32	37
Wrong answer	0	7

**Table 2.9 : SCORES OF MALES AND FEMALES REGARDING
THE FOLOWING PROBLEM NO. 12**

Given a right angled triangle, what are its sides ?

MARKS	MALES	FEMALES		
0	13	16	0	0
1	14	16	14	16
2	1	3	2	6
2.5	0	1	0	2.5
3	3	0	9	0
4	13	14	52	56

Males average score = 1.75

Females average score = 1.61

**Table 2.10 : SCORES OF MALES AND FEMALES
REGARDING THE FOLLOWING PROBLEM**

Given three sides of a triangle there is only one triangle with these sides.
Give justification.

MARKS	MALES	FEMALES
0	22	21
1	11	14
2	6	6
2.5	2	6
3	3	2
4	1	1

Males average score = 0.9111

Females average score = 1.02

**Table 2.11 : SCORES OF MALES AND FEMALES
REGARDING THE FOLLOWING PROBLEM**

Given three angles of a triangle there is only one triangle of these angles.

MARKS	MALES	FEMALES
0	32	35
1	9	11
2	0	2
3	0	0
4	4	2

Males average score = 0.5556

Females average score = 0.46

**Table 2.12 : RANKS OF MALES AND FEMALES REGARDING
THEIR REASONING FOR PROPER UNDERSTANDING
OF MATHEMATICS**

REASON	EXPERTS	MALES	FEMALES
If teachers give more examples of mathematical ideas.	1	2	2
If aesthetics of mathematics is made known.	3	3	3
If applications of mathematics to real life situations are highlighted.	2	1	1

Correlation between Experts and Males : 0.5 Male Index = 3.0

Correlation between Experts and Females : 0.5 Female Index = 2.53

Correlation between Males and Females : 1.0

**Table 2.13 : RANKS OF MALES AND FEMALES REGARDING
LIKING OF MATHEMATICS**

ASPECT	EXPERTS	MALES	FEMALES
Mathematics is an essential tool in science and technology.	1	1	1
Mathematics helps a person to think logically.	9	4	2
Mathematics is all pervading and has application in all walks of life.	2	10.5	3
Mathematics is instrumental to achieve positive results / outcomes and predictions which are real.	10	7	9
Most modern ways of life would hardly have been possible without Mathematics.	3	12.5	6
One can learn mathematics on his own.	15	15	15
Mathematical concepts evolved out of human needs for peaceful co-existence.	14	14	14
Mathematics is a compulsory subject in the schools.	6	4	9
Mathematics provides more job opportunities in computers where Mathematics is essential for computer algorithms.	4	7	7
Mathematics increases the communication power of the world.	7	12.5	12.5
Geometry is very useful in daily life situations like construction of buildings, designing of patterns in textile industry, etc.	5	2	5
Mathematics is a language of science.	13	4	11
Mathematics is very useful in business.	8	7	4
Hallmark of Mathematics is precision.	12	9	9
One of the vastest areas of the world of contemplative beauty is Mathematics and this is sufficient reason for the study of Mathematics.	11	10.5	12.5

Correlation between Experts and Males : 0.3874 Male Index = 3.84
Correlation between Experts and Females : 0.7498 Female Index = 3.81
Correlation between Males and Females : 0.6335

**Table 2.14 : RANKS OF MALES AND FEMALES REGARDING
THEIR DISLIKING OF MATHEMATICS**

Reason	EXPERTS	MALES	FEMALES
Mathematics is a difficult subject	3	4.5	2
Mathematics involves some kind of logical thinking.	2	1	3
Mathematics is a language of complete abstraction.	1	2.5	10
Mathematics is a very boring subject.	17	17	17
Mathematics is full of symbols.	8	13.5	7
Mathematics is made of unrelated topics.	11	13.5	15
New discoveries are seldom made in mathematics.	12	8	8.5
It is difficult to concentrate on mathematics.	4	8	4
Mathematics formulae can be easily forgotten.	7	13.5	5.5
Parents do not encourage to take mathematics.	13	4.5	8.5
Teachers do not teach mathematics well.	5	8	15
Mathematics is a collection of rules and facts to be remembered.	9	2.5	1
Present day mathematics does not have much practical application.	16	8	5.5
It is not easy to score well in Mathematics.	14	13.5	15
Mathematics is meant for only intelligent students.	10	8	13

Mathematics teacher is not good.	6	13.5	12
There are less job opportunities for mathematics, compared to Science subjects.	15	13.5	11

Correlation between Experts and Males : 0.5350 Male Index = 3.19
Correlation between Experts and Females : 0.4207 Female Index = 3.34
Correlation between Males and Females : 0.6173

Table 2.15: RANKS OF MALES AND FEMALES REGARDING THE REASONS FOR NOT TO HAVE TOP LEVEL MATHEMATICIANS

ASPECT	EXPERTS	MALES	FEMALES
Women are down-to-earth practical while mathematics is abstract.	5	6.5	7
Parents do not agree girls to take up higher mathematics.	3	6.5	3
Genetic factors of females do not promote creative work in Mathematics.	7	8	4.5
Social factors do not favour the girls to go for higher studies in Mathematics.	1	1	4.5
Girls' self-esteem decreases during adolescence more than that of boys.	6	4	2
Vocational interests of women are different.	2	2.5	1
Brain system of girls is different from that of boys.	8	5	8
Girls prefer careers that involve living things (like Biology, Medicine).	4	2.5	6

Correlation between Experts and Males : 0.6266 Male Index = 3.20
Correlation between Experts and Females : 0.4791 Female Index = 3.08
Correlation between Males and Females : 0.2182

Table 3: INDICES OF DIFFERENT ASPECTS

Aspect	Gender	Index		
		Teacher Educators	Students	Teachers
Perception of Mathematics	M	9.08	12.97	5.0
	F	8.43	13.40	6.0
Liking of Mathematics	M	16.85	8.23	3.84
	F	23.75	7.62	3.81
Disliking of Mathematics	M	13.08	1.90	3.19
	F	19.4	3.54	3.34
Understanding of Mathematics	M	---	3.00	3.0
	F	---	3.41	2.53
Liking of different branches of Mathematics	M	2.51	3.09	---
	F	3.18	3.38	---
Reasons for not to have top level women Mathematicians	M	9.85	---	3.20
	F	7.43	---	3.08

The opinions of males and females regarding the perception of mathematics were shown in table 2.1. From this table it was observed that the correlation between males and experts was .8857 where as that of females was .7714. Similarly the correlation between males and females was .9429. These figures indicate that there was significant relationship between males opinion and females opinion regarding the perception of mathematics.

From table 2.2 it was very interesting to note that females were having very high concordance in liking of different branches of mathematics with

the experts but it was not true in case of males. Males and females have the same reasons for liking and disliking of the individual branches of mathematics like algebra, arithmetic and geometry. But they were different when compared to those of experts. Males and females agreed in giving their reasons for better understanding of mathematics even though both these groups have no perfect concordance with the experts (table 2.12). Females were closer to the experts regarding their liking of mathematics. But there was no significant relation between males and females in liking of mathematics. This was obvious from table 2.13.

While giving the reasons for disliking mathematics, all the three groups differed. Of course there was little relationship between males and females in this regard (table 2.14).

The responses for not to have top level women mathematicians were listed separately for experts, males and females in table 2.15. It was observed that males and females were very much different in their reasons. Both males and experts mentioned that 'social factors do not favour girls to go for higher studies in mathematics' as the main reason where as females mentioned that 'vocational interests of women are different' as the main reason. However males and experts have mentioned this reason as second in priority. The overall order of the reasons for gender bias in mathematics is as given below.

List of the comments given by the Participants

1. Encouragement from the parents is less for girls
2. No sex difference in Mathematics

3. Have no exact idea about the sex difference
4. Women do not have more exposure .
5. Girls prefer to settle in life sooner than boys
6. Women do not prefer mental stress that is needed in Mathematics
7. Women cannot have the concentration that is needed in mathematics
8. At lower level, girls do better than boys in Mathematics
9. Women are capable to become good Mathematicians if proper opportunities are given
10. Genetic factor plays an important role
11. For higher Mathematics, the abilities would be different
12. Girls do not like Mathematics at higher level
13. Boys think more logically and have better exposure
14. Computation abilities of boys are better
15. Girls are having more mathematical abilities
16. Girls are having more thinking capabilities
17. Girls are more active .

Main Findings:

1. Boys were good in abstract thinking and symbolising concepts in mathematics where as girls were good in logical thinking and mathematical modeling.
2. Both males and females have the same perception of mathematics.
3. Males and females have the same level of liking mathematics.
4. Males and females gave the same reasons for liking and disliking of the individual branches of mathematics like arithmetic, algebra and geometry.
5. Males stated that 'social factors do not favour girls to go for higher studies in mathematics' as the main reason for not to have top level women mathematicians. But females stated that ' vocational interests of women are different' as the main reason.

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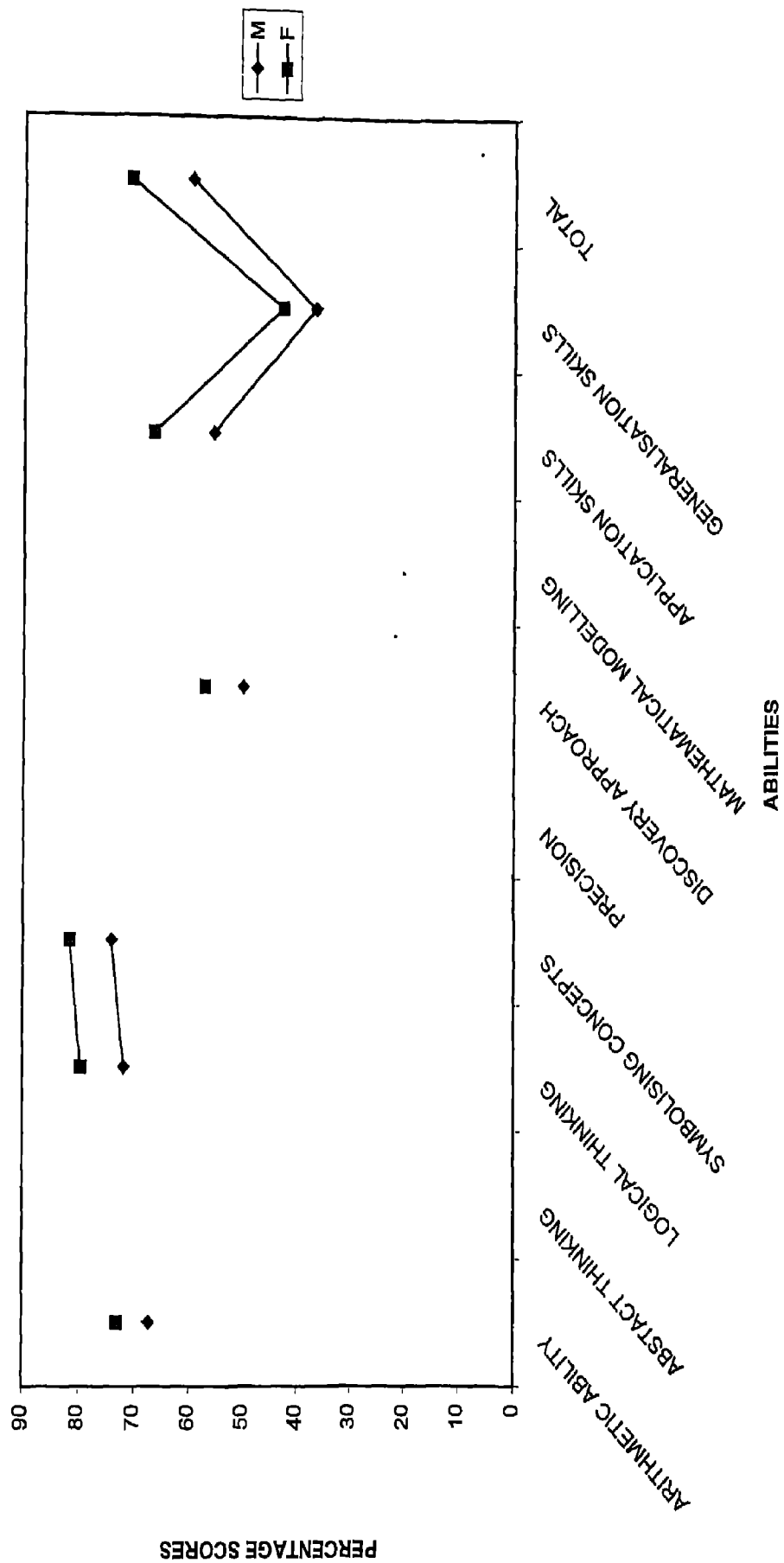
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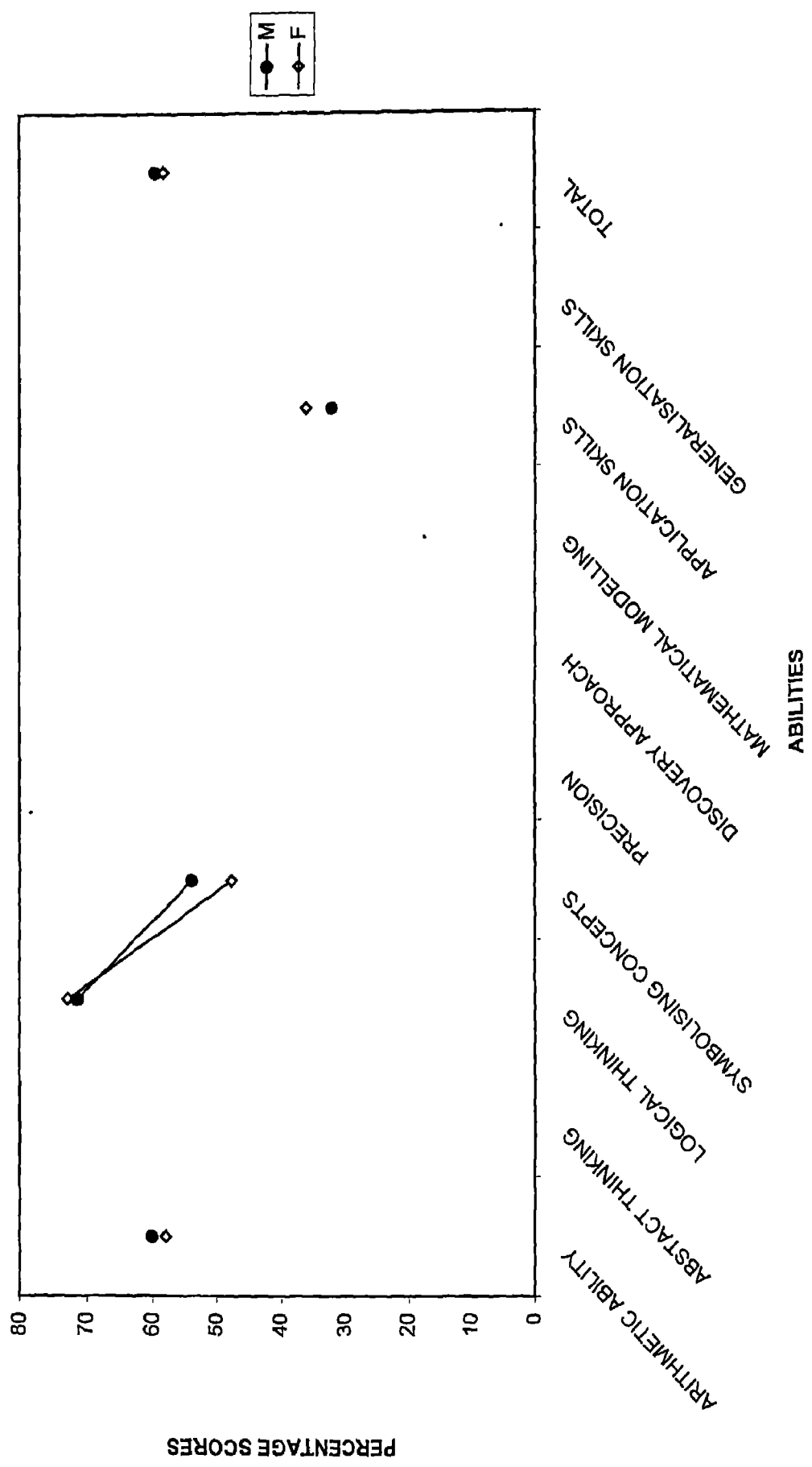
APPENDIX - I

GRAPHICAL REPRESENTATION

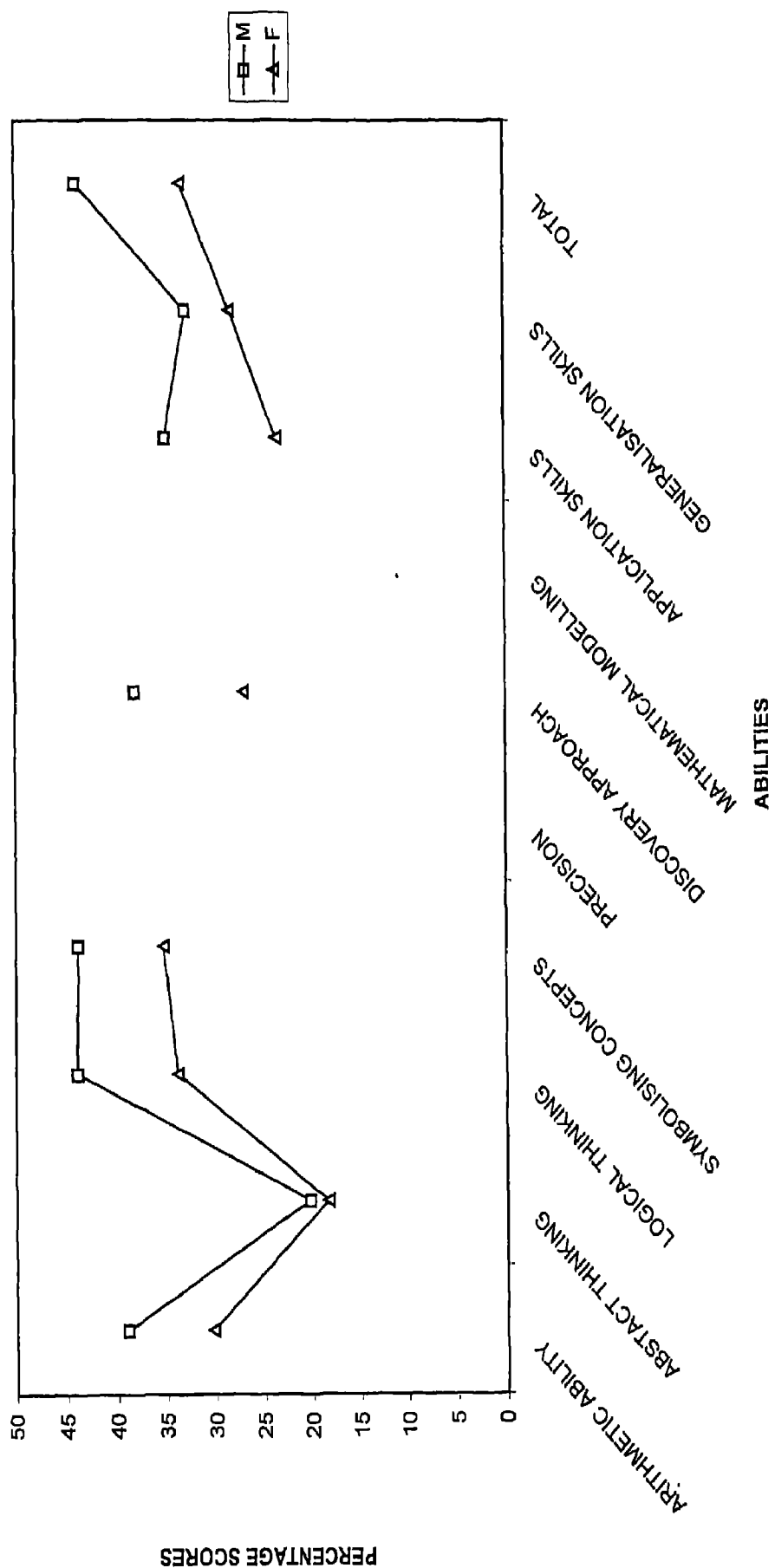
COMPARISON OF SCORES OBTAINED BY MALES AND FEMALES IN CLASS 3



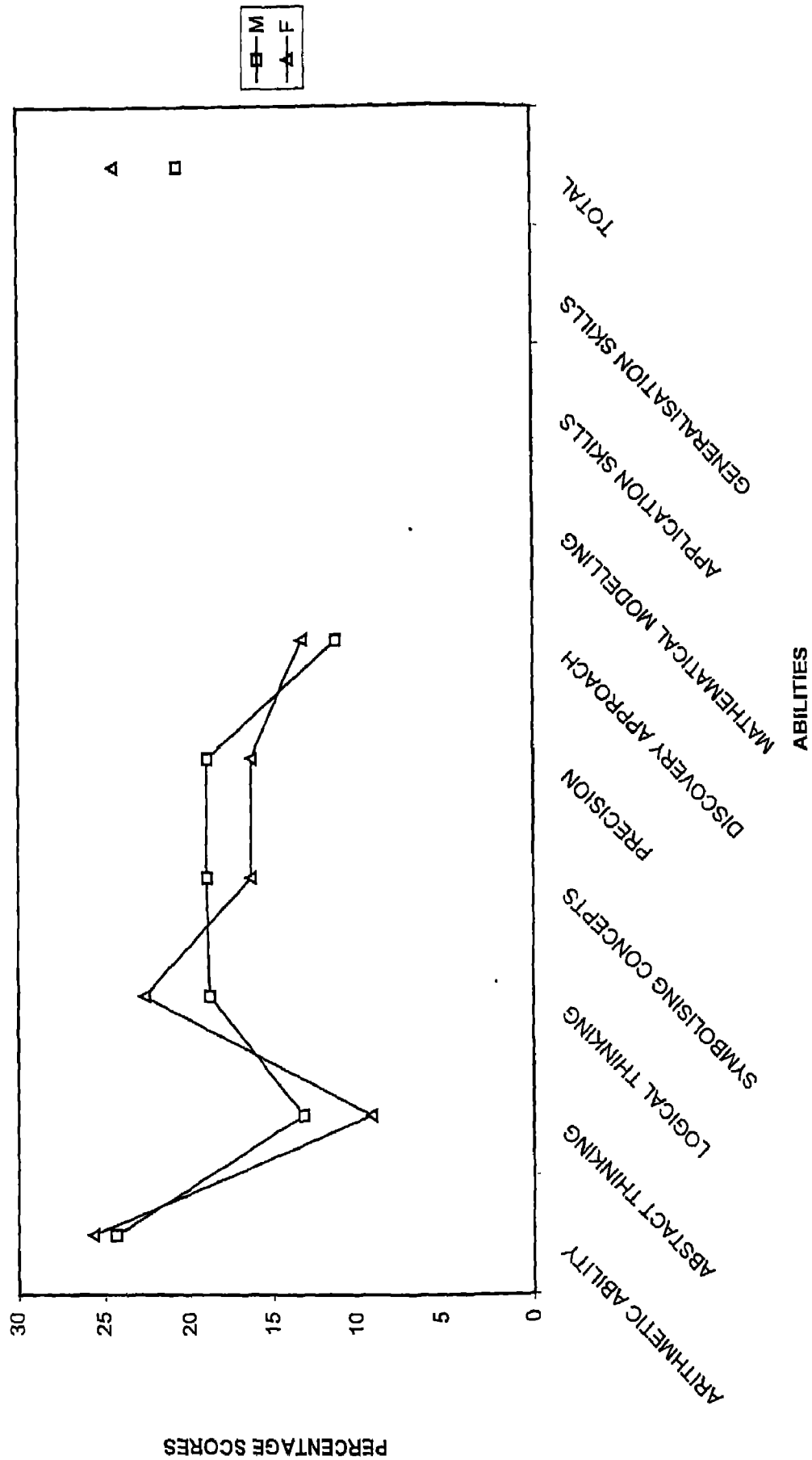
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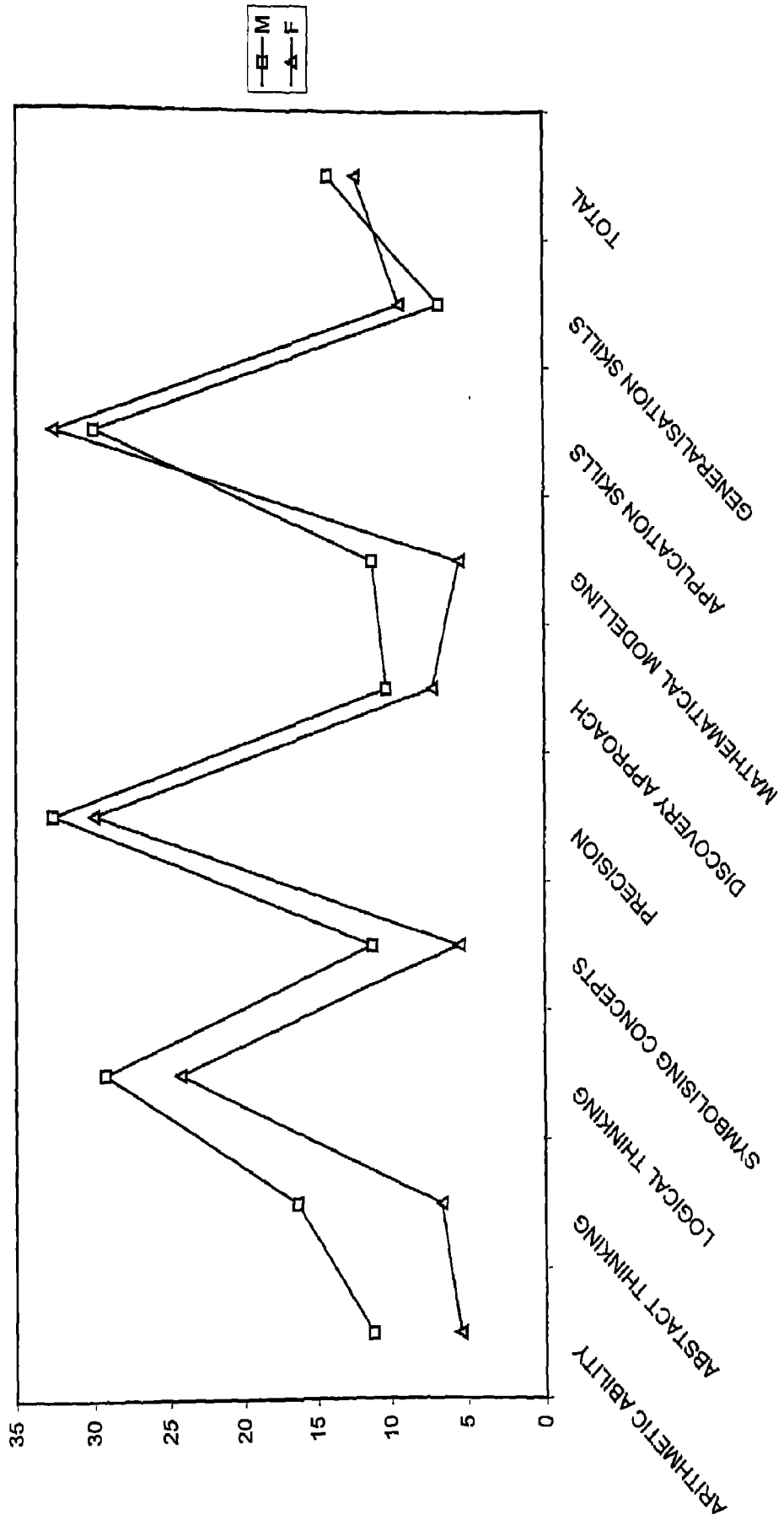
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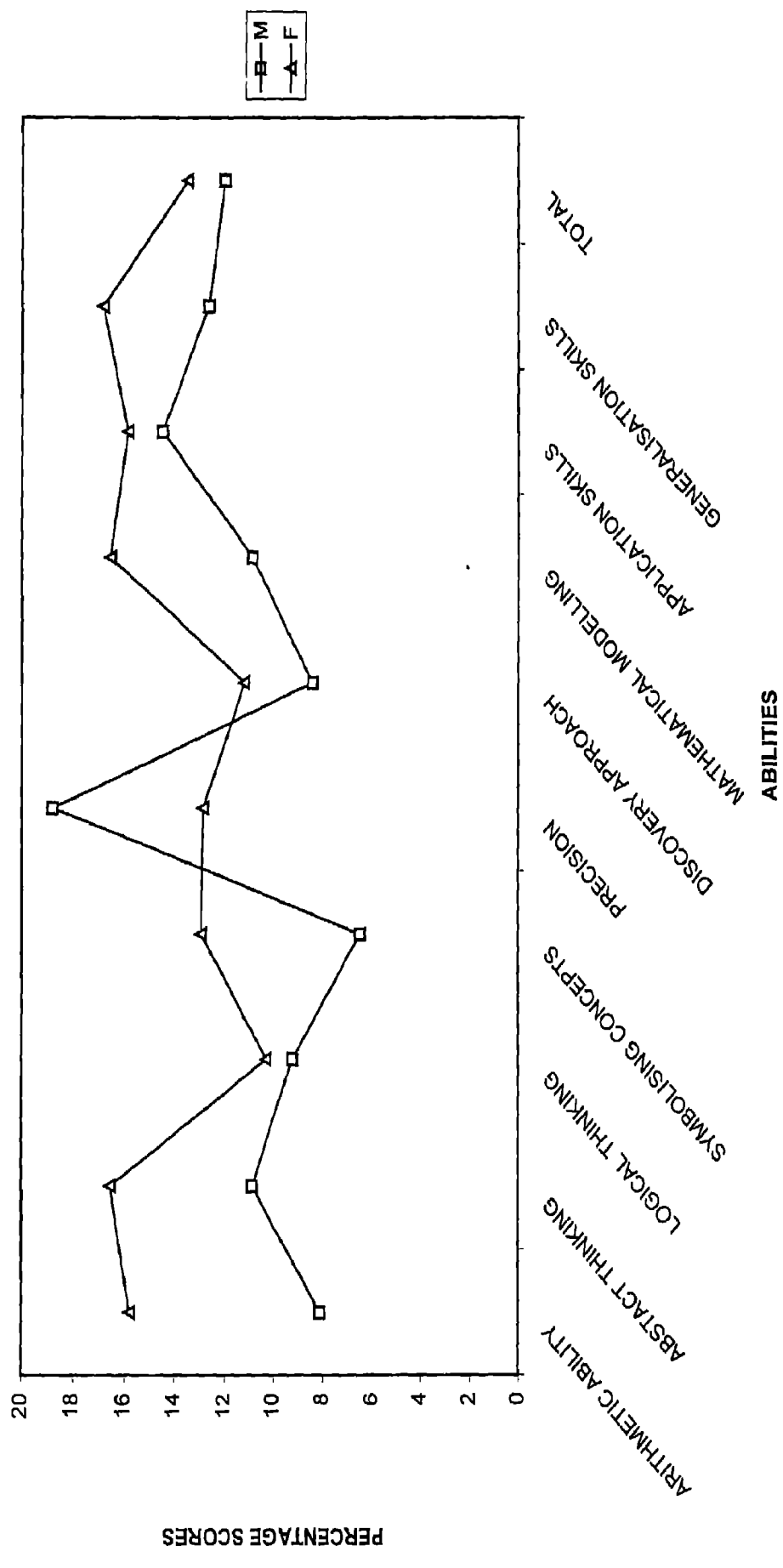
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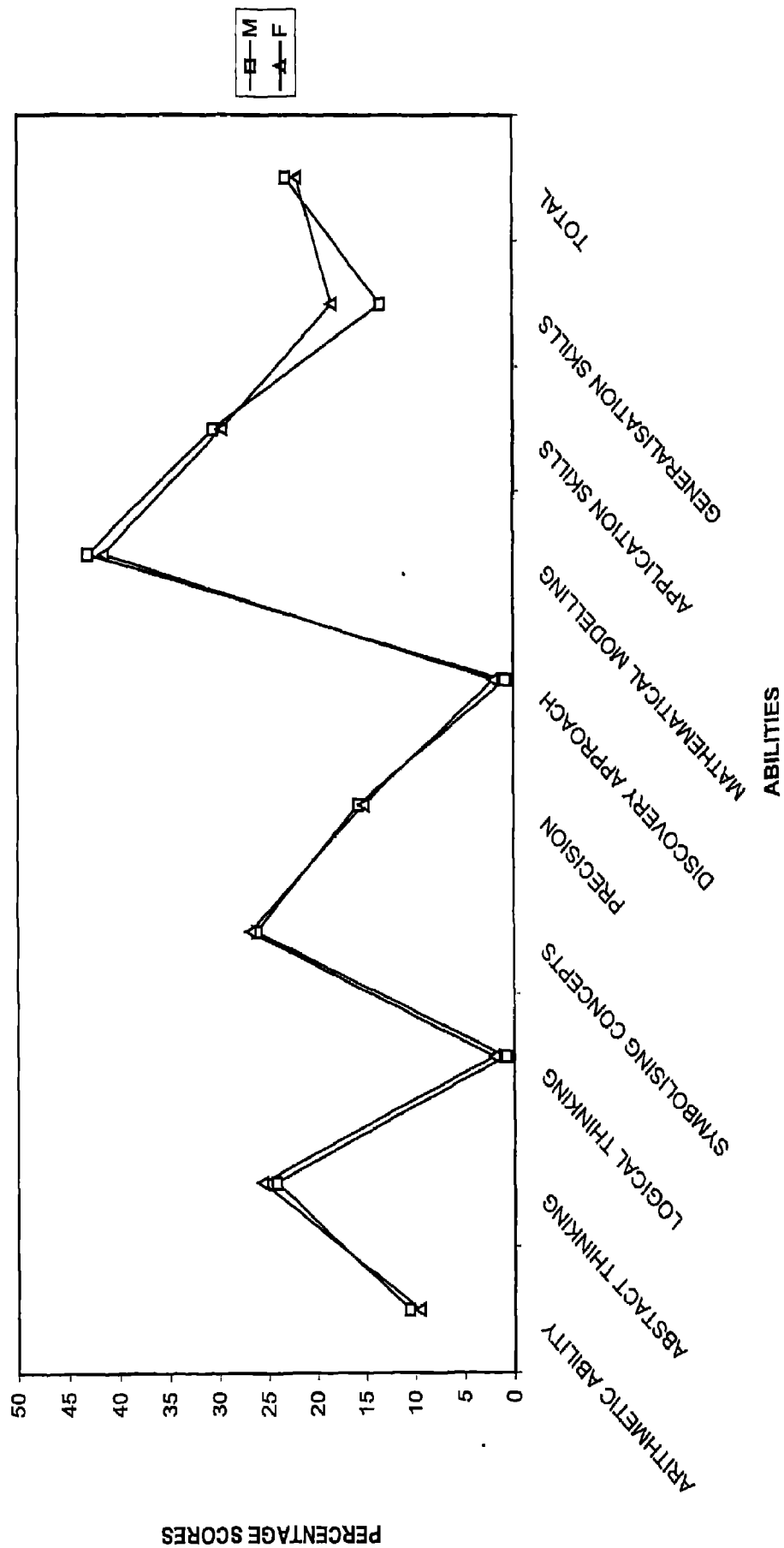
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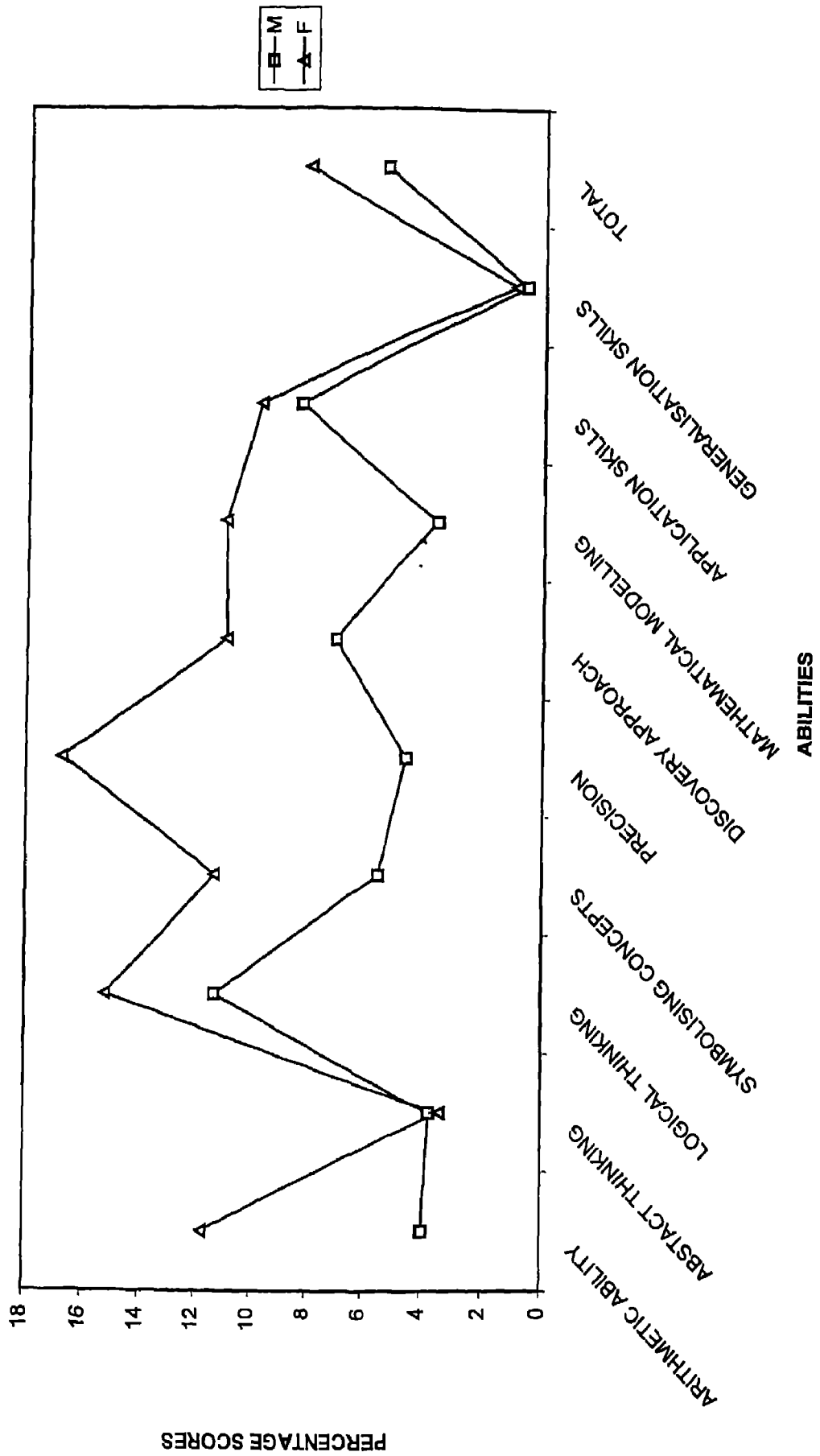
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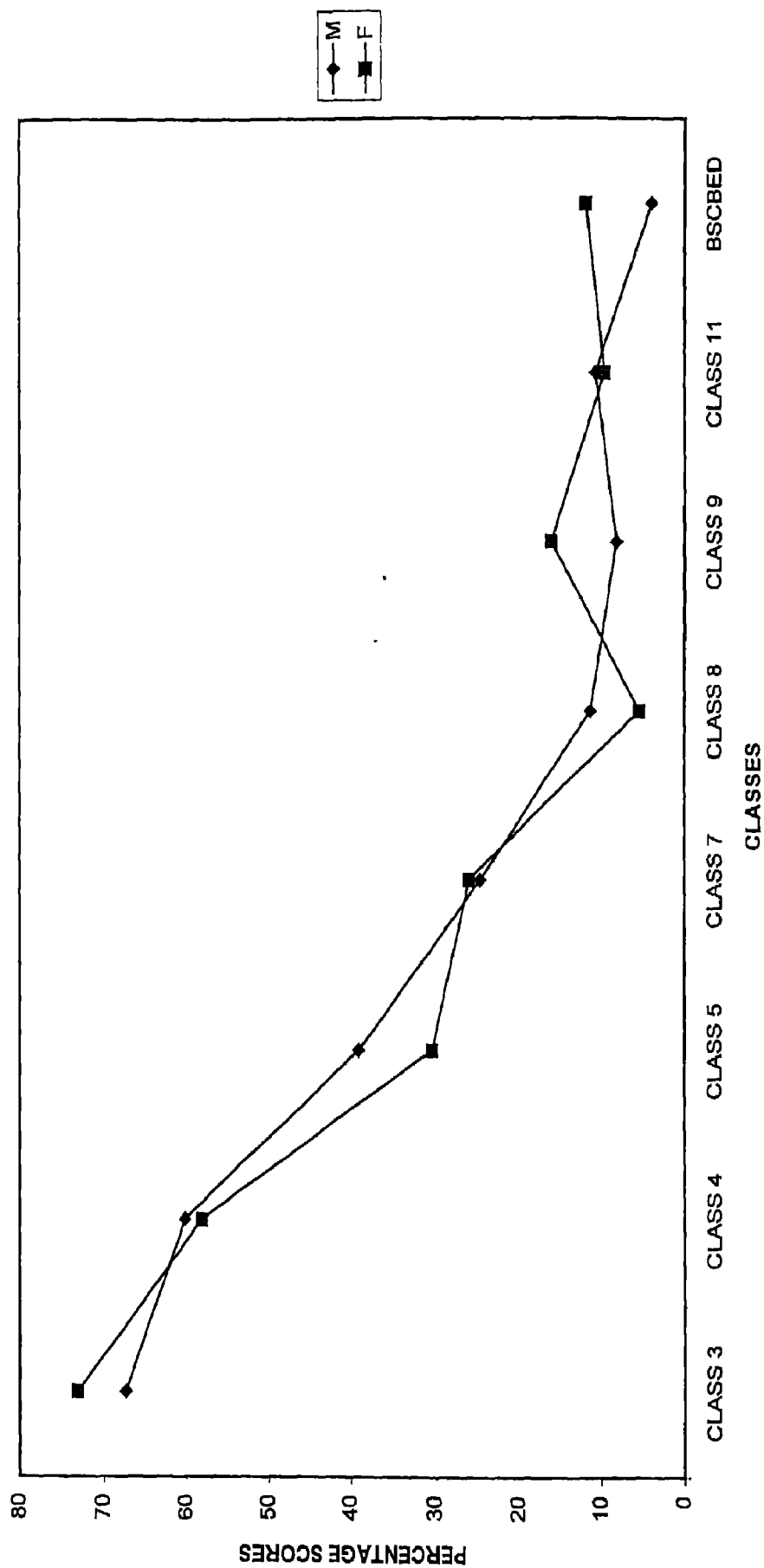
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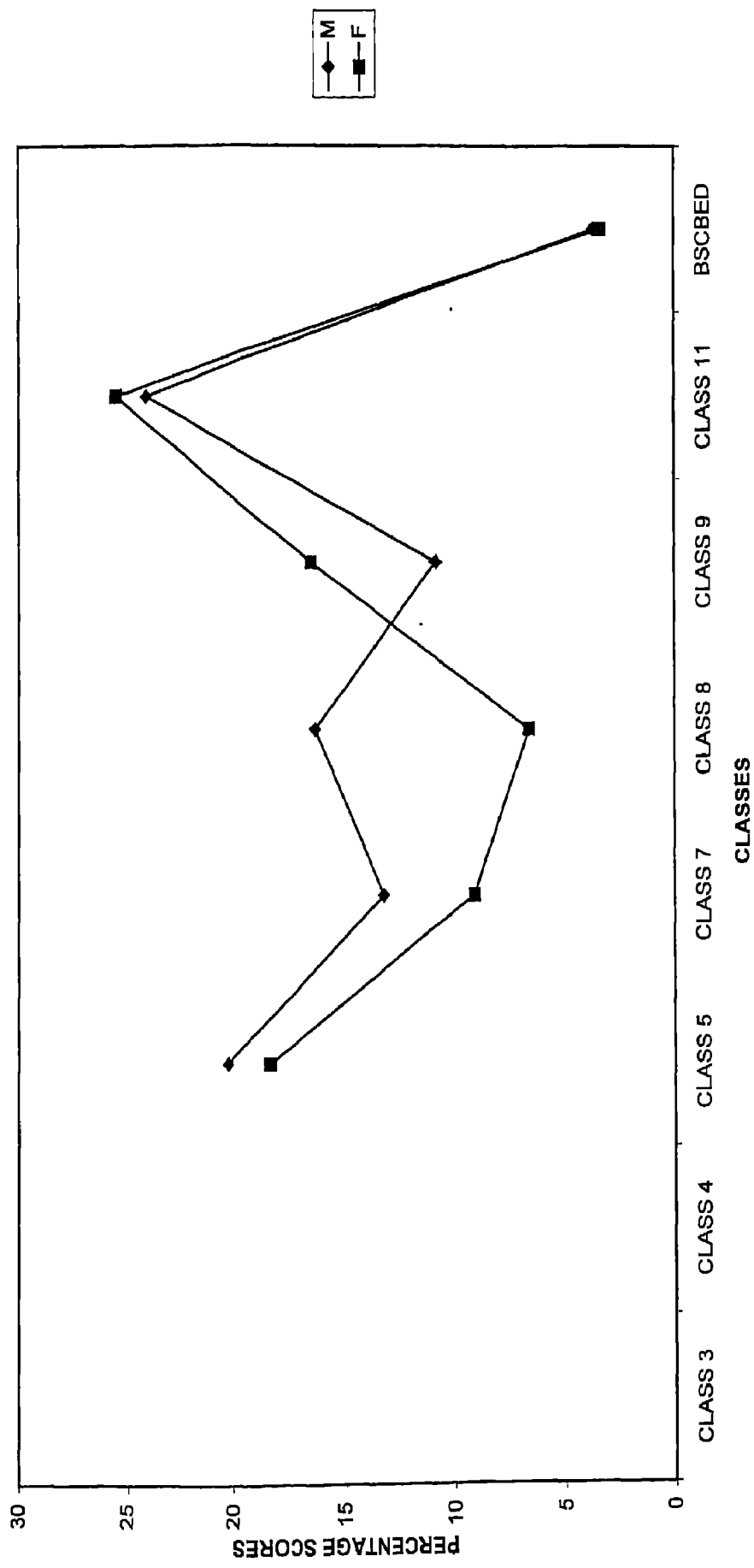
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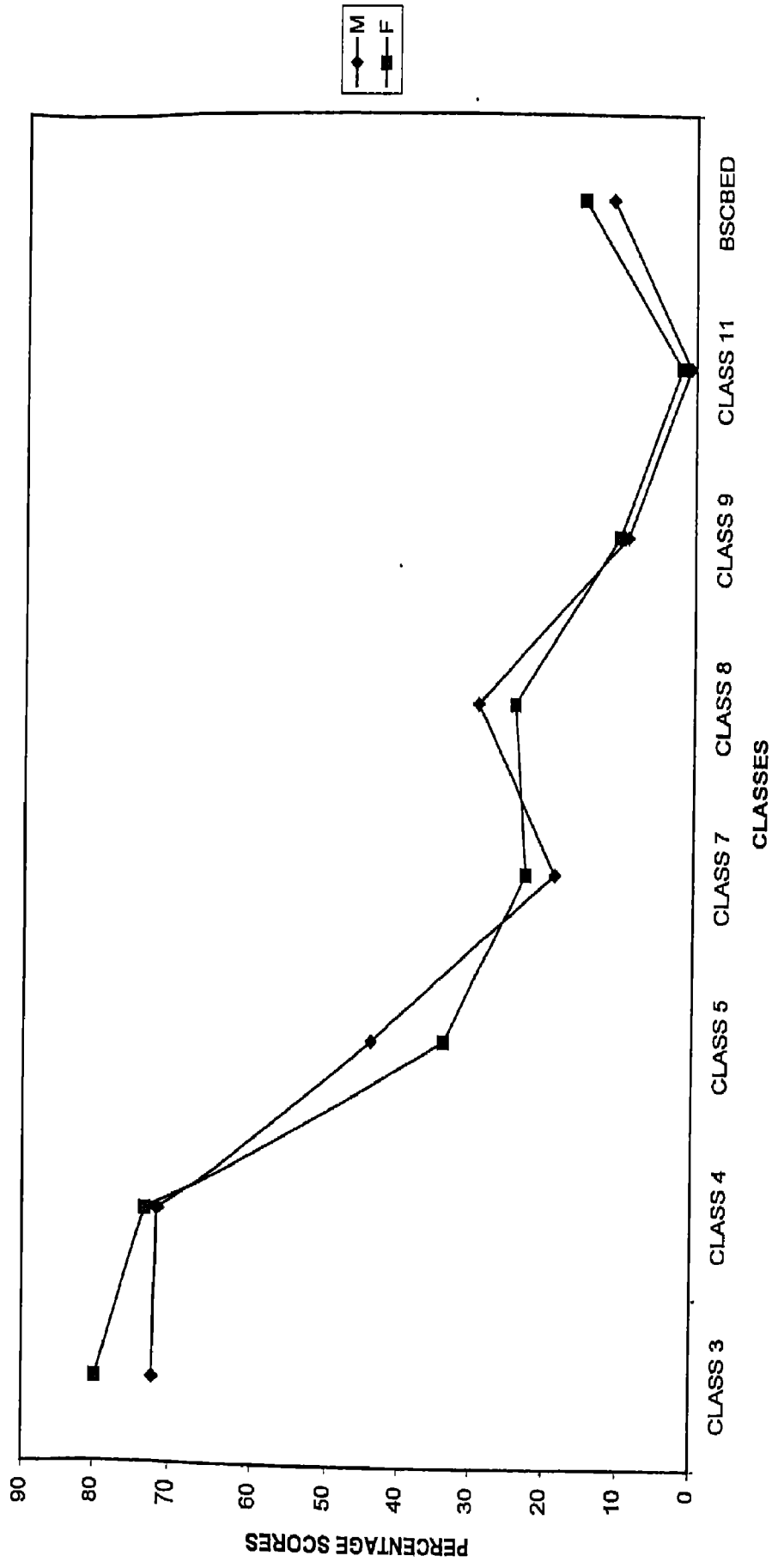
COMPARISON OF SCORES OBTAINED BY MALES AND FEMALES REGARDING ARITHMETIC ABILITY



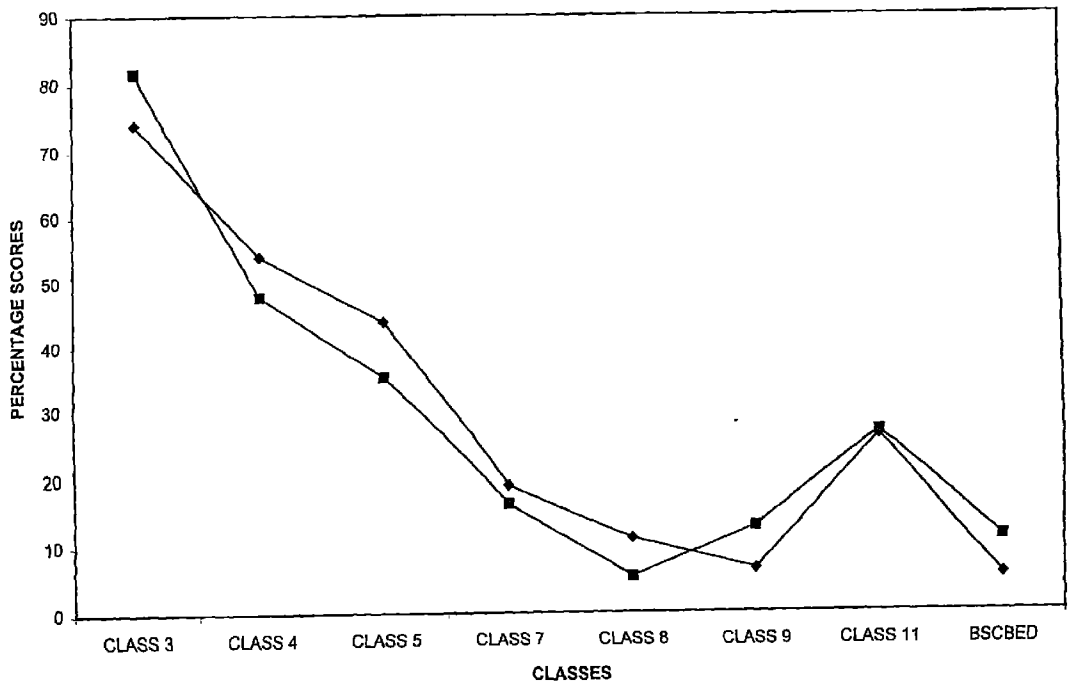
COMPARISON OF SCORES OBTAINED BY MALES AND FEMALES REGARDING ABSTRACT THINKING



COMPARISON OF SCORES OBTAINED BY MALES AND FEMALES REGARDING LOGICAL THINKING

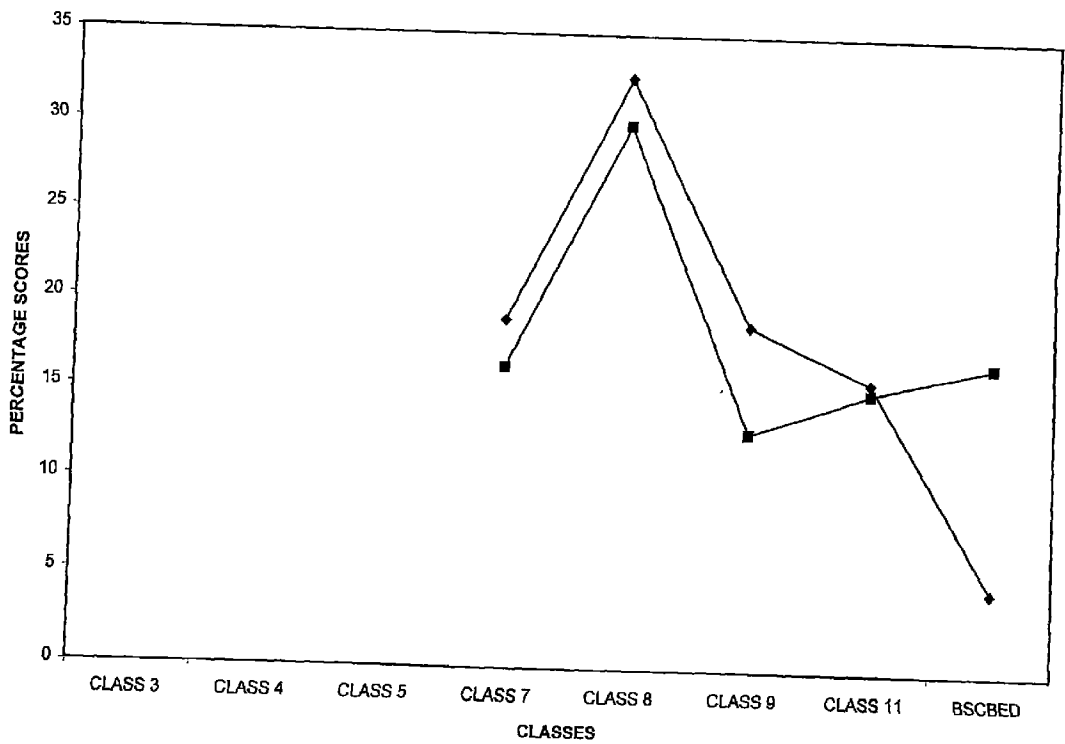


COMPARISON OF SCORES OBTAINED BY MALES AND FEMALES REGARDING
SYMBOLISING CONCEPTS



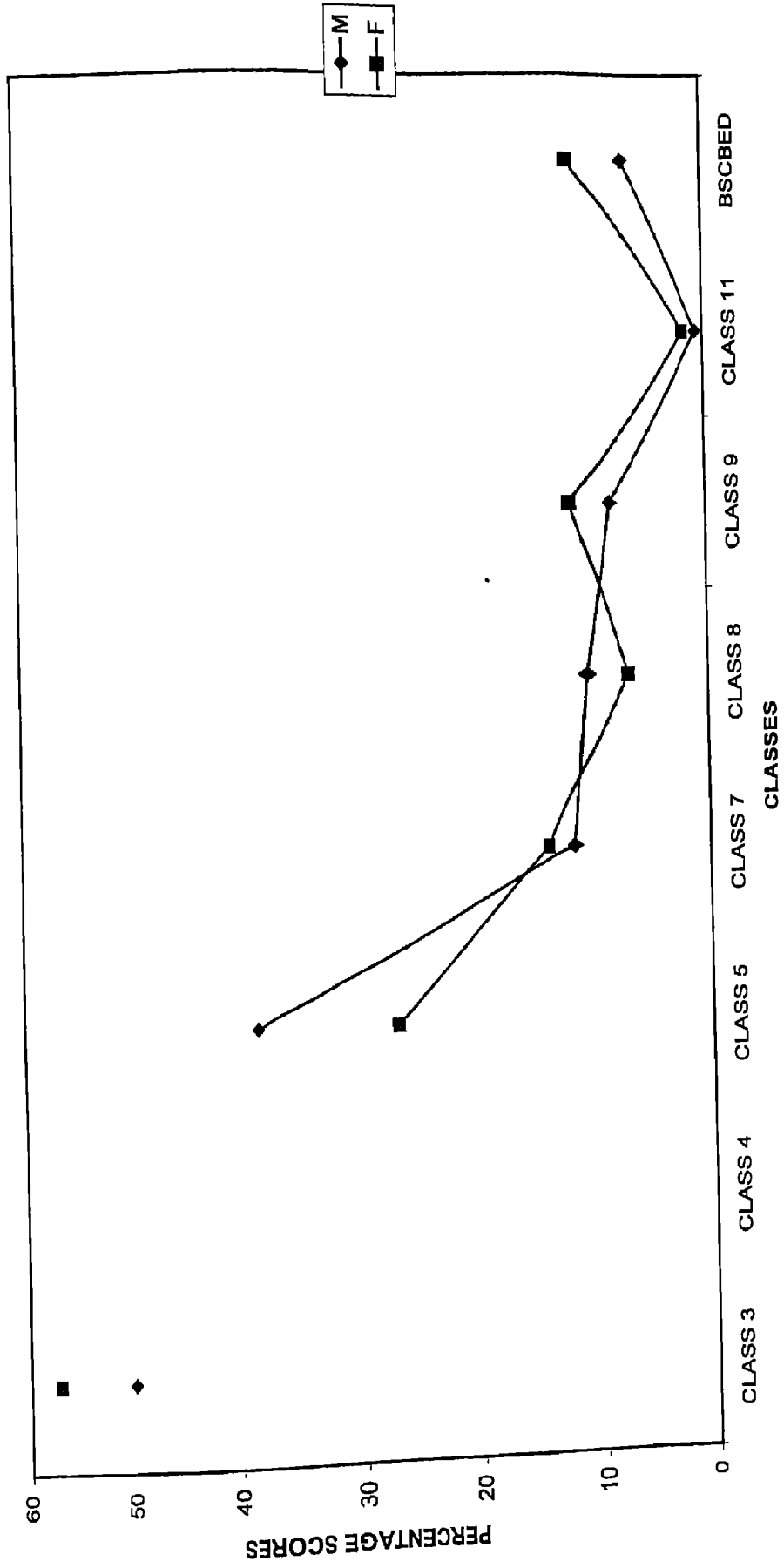
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COMPARISON OF SCORES OBTAINED BY MALES AND FEMALES REGARDING PRECISION

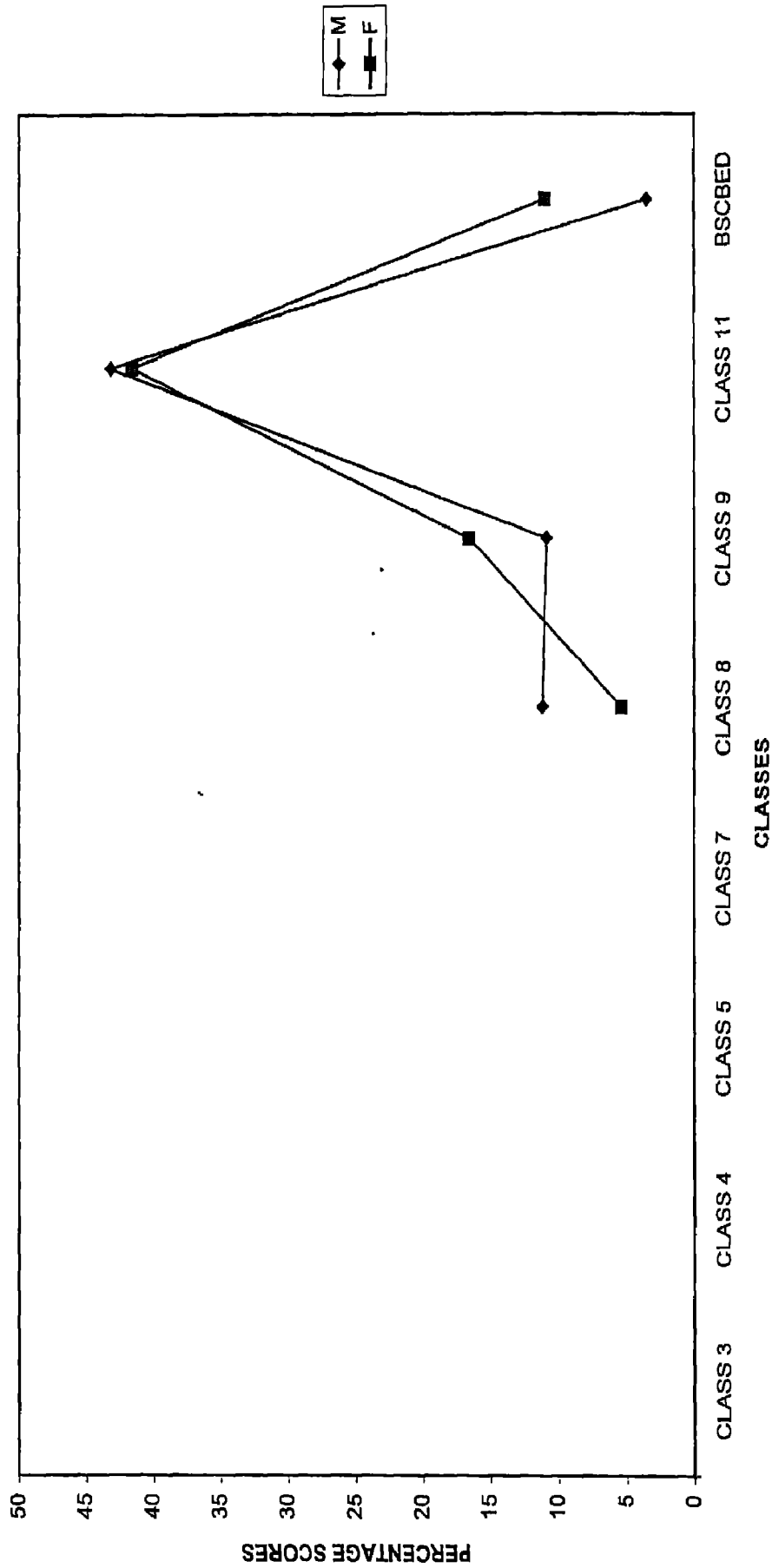


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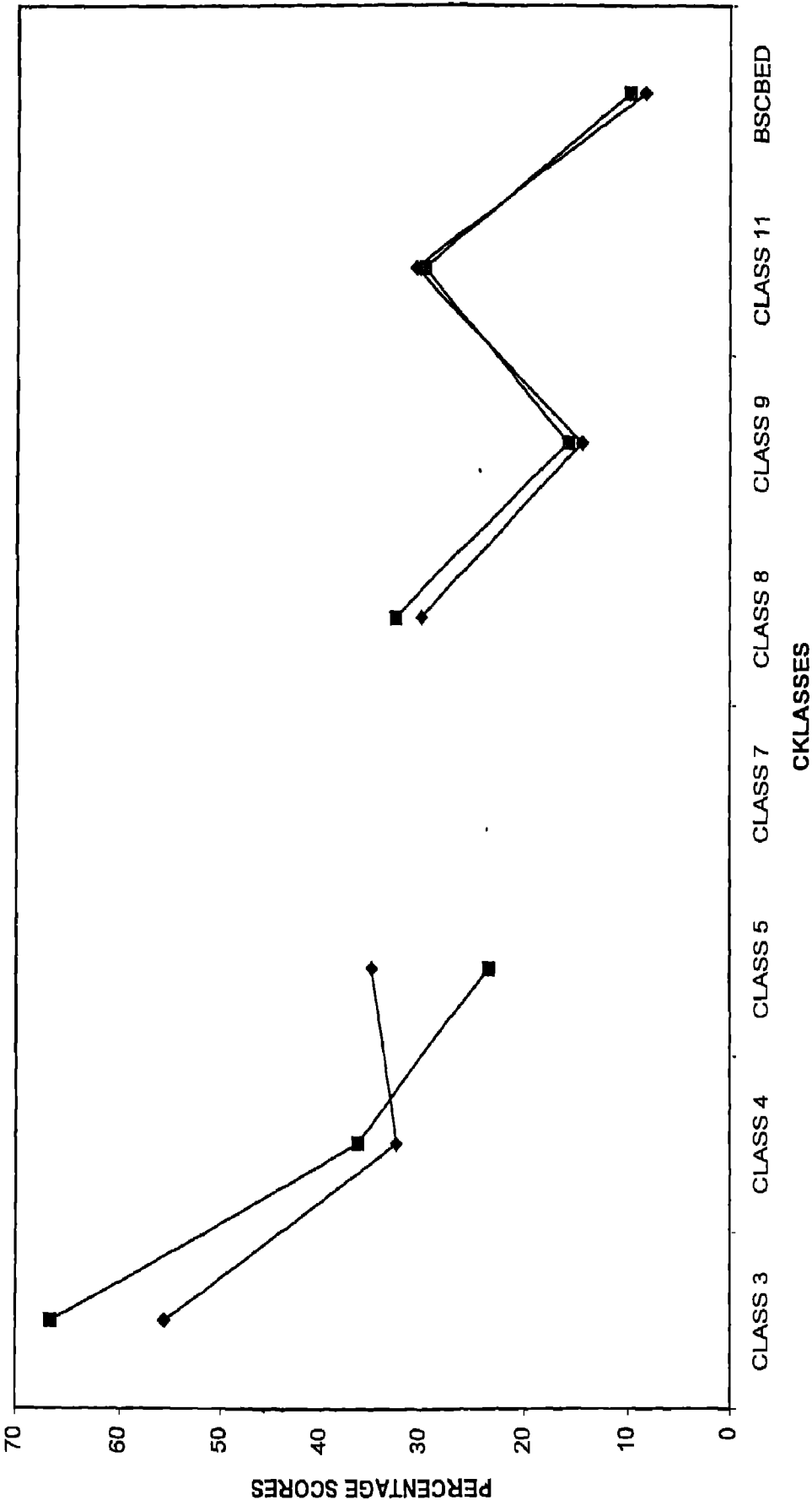
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APPROACH



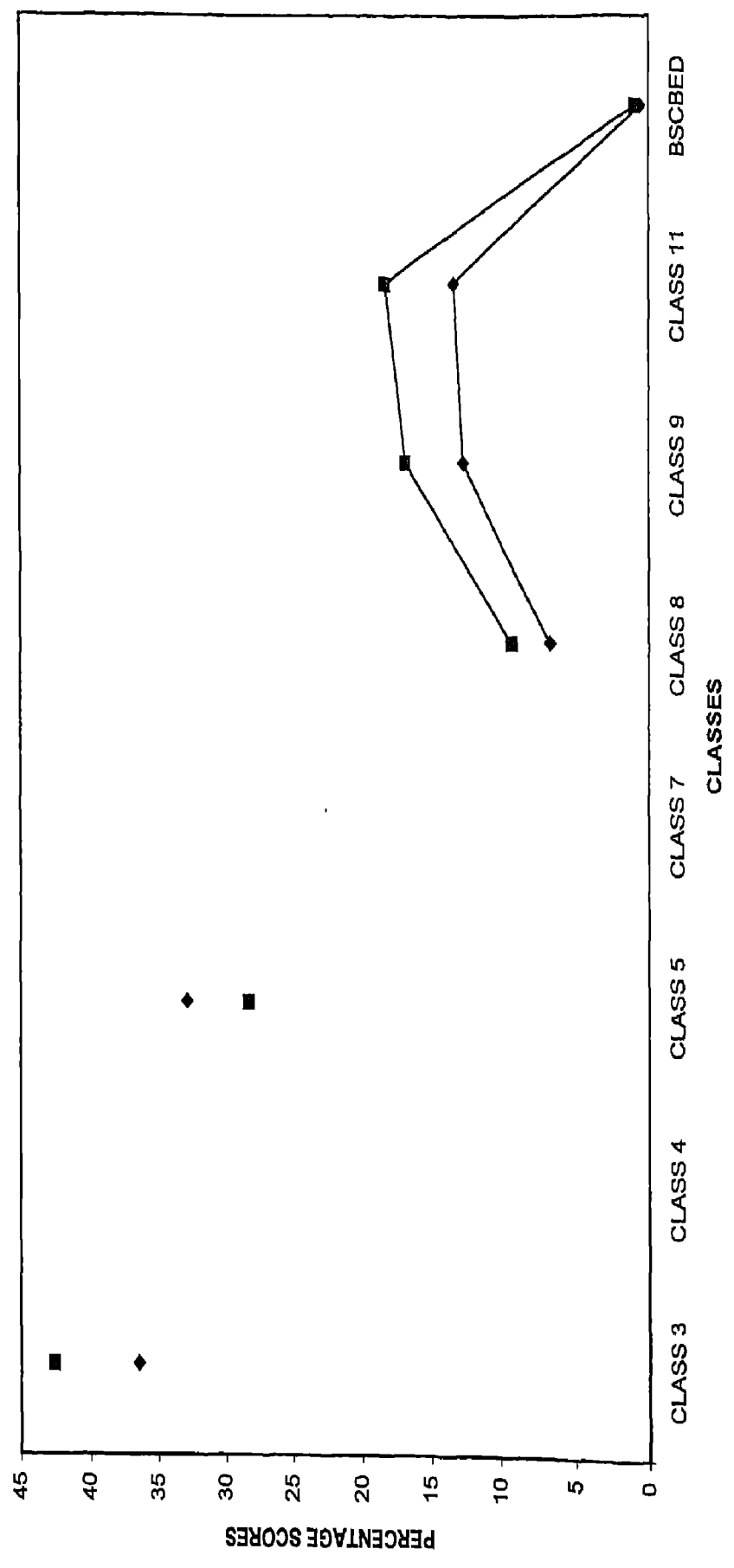
COMPARISON SCORES OBTAINED BY MALES AND FEMALES REGARDING MATHEMATICAL MODELLING



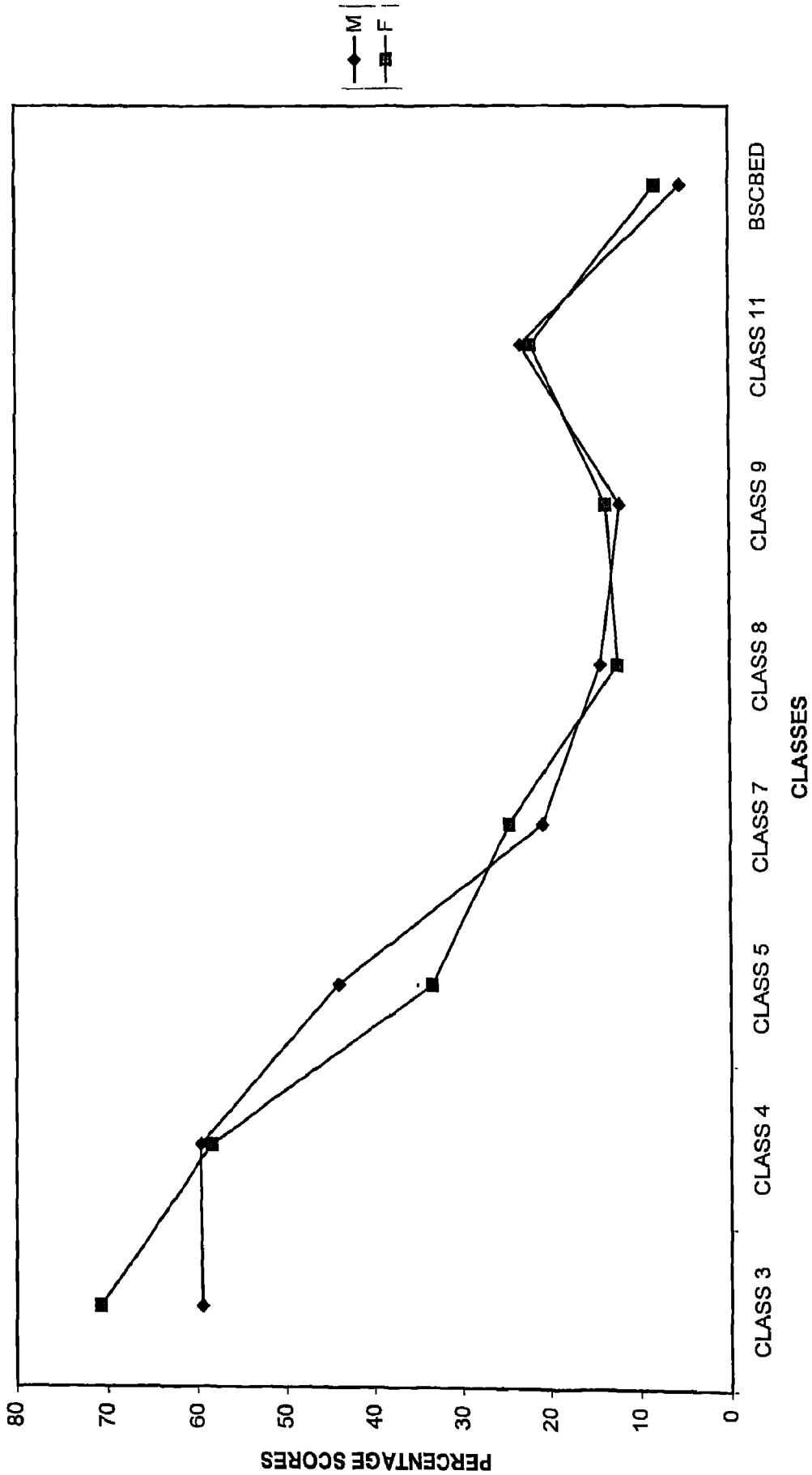
COMPARISON OF SCORES OBTAINED BY MALES AND FEMALES REGARDING APPLICATION SKILLS



COMPARISON OF SCORES OBTAINED BY MALES AND FEMALES REGARDING
GENERALISATION SKILLS



COMPARISON OF SCORES OBTAINED BY MALES AND FEMALES



APPENDIX – I I

QUESTIONNAIRES

REGIONAL INSTITUTE OF EDUCATION, MYSORE-6

Instruction:

Some information regarding Mathematics is given below. You are requested to give your opinion by putting a ($\sqrt{}$) against the items (you may tick more than one).

1. Mathematics can be viewed as given below:

- i) God made the natural numbers and the rest of mathematics is the work of man.
- ii) It is not abstraction, which makes mathematics difficult, rather it is precision. Mathematics is difficult because unlike any other discipline, it demands complete precision.
- iii) One of the things that mathematicians know and the rest of us do not is that all of mathematics follows inevitably from a small collection of fundamental rules.
- iv) Mathematics is the abstract key, which turns lock of the physical universe.

- v) The greatest book of nature can be read only by those who know the language in which it was written and this language is mathematics.
- vi) Mathematics enjoys special esteem above all other sciences because its laws are absolute and indisputable while in other sciences to some extent debatable.

2. I like mathematics because

- i) mathematics is an essential tool in science and technology
- ii) mathematics helps a person to think logically
- iii) mathematics is all pervading and has application in all walks of life
- iv) mathematics is instrumental to achieve positive results/outcomes and predictions which are real
- v) most modern ways of life would hardly have been possible without mathematics
- vi) one can learn mathematics on his own
- vii) mathematics concepts evolved out of human needs for peaceful coexistence
- viii) mathematics is the compulsory subject in the schools

- ix) mathematics provide more job opportunities in computers where mathematics is essential for computer algorithms
- x) mathematics increases the communication power of the world
- xi) geometry is very useful in daily life situations like construction of buildings, designing of patterns, textile industry etc.
- xii) mathematics is a language of science
- xiii) mathematics is very useful in business
- xiv) mathematics is hall-mark of precision
- xv) one of the vastest areas of the world of contemplative beauty is mathematics and this is sufficient reason for the study of mathematics.

3. I do not like mathematics because

- i) mathematics is a difficult subject
- ii) mathematics involves some kind of logical thinking
- iii) mathematics is a language of complete abstraction
- iv) mathematics is a very boring subject
- v) mathematics is full of symbols
- vi) mathematics is made of un-related topics

- vii) new discoveries are seldom made in mathematics
- viii) it is difficult to concentrate on mathematics
- ix) mathematics formulae can be easily forgotten
- x) parents do not encourage to take mathematics
- xi) teachers do not teach mathematics well
- xii) mathematics is a collection of rules and facts to be remembered
- xiii) present day mathematics do not have much practical application
- xiv) it is not easy to score well in mathematics
- xv) mathematics is meant for only intelligent students
- xvi) mathematics teacher is not good
- xvii) there are less job opportunities for mathematics, compared to science subjects.

4. I like very much

- i) arithmetic
- ii) algebra
- iii) geometry

because -----

5. $-2 \times -3 = 6$

because -----

6. There are not many top level women mathematicians because
- i) women are down-to-earth practical while mathematics is abstract
 - ii) parents do not agree girls to take up higher mathematics
 - iii) genetic factors of female do not promote creative work in mathematics
 - iv) social factors do not favour the girls to go for higher studies in mathematics
 - v) girls self-esteem decreases during adolescence more than that of boys
 - vi) vocational interests of women are different
 - vii) brain system of girls is different from that of boys
 - viii) girls prefer careers that involve living things (like Biology Medicine).

REGIONAL INSTITUTE OF EDUCATION, MYSORE –6

Name of the Student :

Name of the School:

Instructions for Students

Some information regarding Mathematics is given below. You are requested to give your opinion by putting (✓) against the items. You may tick one or more items.

1. Mathematics is a study of

- (i) Numbers
- (ii) Symbols
- (iii) Geometrical figures
- (iv) Computations
- (v) Proofs
- (vi) Sets

2. I like Mathematics because

- i) it deals with numbers and numbers are useful.
- ii) it has precise answers.
- iii) it has logic which is interesting.
- iv) it has applications in almost every branch of knowledge.

- v) it has truths like say $2 + 1 = 3$, $2 + 2 = 4$, etc. which are universally true.
- vi) it has symbols which can be used to represent any situation.

3. I dislike Mathematics because

- i) it is full of symbols which are difficult to understand.
- ii) it has very peculiar computations such as $(-2) + (-2) = -4$ but $(-2) \times (-2) = 4$.
- iii) there is no motivation in Mathematics as in other subjects.
- iv) the proofs are difficult to understand.
- v) too many drilling problems are boring and too many rules to remember.

4. The branch of Mathematics I like the most is

- i) algebra
- ii) arithmetic
- iii) geometry

5. I like algebra because

- i) algebra is more powerful than arithmetic.
- ii) it has symbols.
- iii) algebra is more general compared to arithmetic.

6. I dislike algebra because

- i) it has symbols
- ii) it is not meaningful as arithmetic.

- iii) it is difficult to understand formulae like $a^m \times a^n = a^{m+n}$, $a^0 = 1$, etc.
7. I like geometry because
- i) it has beautiful figures and similar figures we can see in different walks of life.
 - ii) construction of geometrical figures is an interesting activity.
 - iii) many properties can be understood through figures only and no need to remember properties as rules.
 - iv) the proofs in geometry are easy to understand.
8. I like arithmetic because
- i) it is useful in daily life.
 - ii) it has no symbols
 - iii) it helps one to measure precisely the quantities such as length, area, volume, etc.
9. Mathematics can be understood better if
- i) teachers give more examples of mathematical ideas.
 - ii) mathematical beauty is made known.
 - iii) we are given books specially designed for us to study independently.
10. Tick one or more of the following :
- i) I dislike arithmetic.
 - ii) I dislike geometry.
 - iii) Mathematics should not be made compulsory.

iv) Mathematics helps person to think logically.

v) Mathematics is a language of science.

11. Since $\frac{ab}{ac} = \frac{b}{c}$ then it is natural to expect that $\frac{a+b}{a+c} = \frac{b}{c}$. Do you agree with this statement? Tick one box.

Yes ☐ No ☐

12. Given a right angled triangle, what are its sides?

13. Which of the following is true? Give justification.

- i) Given three sides of a triangle, there is only one triangle with these sides.
- ii) Given three angles of a triangle there is only one triangle of these angles.

14. Do you like to give your own comments on Mathematics?

Yes ☐ No ☐

If yes, your comments.

REGIONAL INSTITUTE OF EDUCATION, MYSORE 570 006

Name and Designation :

Institution :

A. Some information regarding Mathematics is given below. You are requested to give your opinion by putting tick (✓) against the items (you may tick more than one).

I. Mathematics can be viewed as given below :

- i) God made the natural numbers and the rest of mathematics is the work of man.
- ii) It is not abstraction, which makes mathematics difficult, rather it is precision. Mathematics is difficult because unlike any other discipline, it demands complete precision.
- iii) One of the things that mathematicians know and the rest of us do not is that all of mathematics follows inevitably from a small collection of fundamental rules.
- iv) Mathematics is the abstract key, which turns lock of the physical universe.
- v) The greatest book of nature can be read only by those who know the language in which it was written and this language is mathematics.
- vi) Mathematics enjoys special esteem above all other sciences because its laws are obsolete and indisputable while in other sciences to some extent debatable.

II. Mathematics is a study of

- i) Numbers
- ii) Symbols
- iii) Geometrical figures
- iv) Computations
- v) Proofs
- vi) Sets
- vii) Abstract ideas

III. Mathematics can be understood better if

- i) teachers give more examples of mathematical ideas.
- ii) Aesthetics of mathematics is made known.
- iii) Applications of mathematics to real life situation are highlighted

B. Some statements regarding Mathematics are given below. You are requested to indicate your opinion by ticking the appropriate option.

I. People like Mathematics because					
Mathematics is an essential tool in science and technology.	Strongly Agree	Agree	Un-Decided	Dis-agree	Strongly Disagree
Mathematics helps a person to think logically.	Strongly Agree	Agree	Un-Decided	Dis-agree	Strongly Disagree
Mathematics is all pervading and has application in all walks of life	Strongly Agree	Agree	Un-Decided	Dis-agree	Strongly Disagree
Mathematics is instrumental to achieve positive results/outcomes and predictions which are real.	Strongly Agree	Agree	Un-Decided	Dis-agree	Strongly Disagree
Most modern ways of life would hardly have been possible without mathematics.	Strongly Agree	Agree	Un-Decided	Dis-agree	Strongly Disagree
One can learn mathematics on his own.	Strongly Agree	Agree	Un-Decided	Dis-agree	Strongly Disagree
Mathematical concepts evolved out of human needs for peaceful coexistence.	Strongly Agree	Agree	Un-Decided	Dis-agree	Strongly Disagree
Mathematics is the compulsory subject in the schools.	Strongly Agree	Agree	Un-Decided	Dis-agree	Strongly Disagree
Mathematics provides more job opportunities in computers where mathematics is essential for computer algorithms.	Strongly Agree	Agree	Un-Decided	Dis-agree	Strongly Disagree
Mathematics increases the communication power of the world	Strongly Agree	Agree	Un-Decided	Dis-agree	Strongly Disagree

Mathematics is a collection of rules and facts to be remembered.	Strongly Agree	Agree	Un-Decided	Dis-agree	Strongly Disagree
Present day mathematics does not have much practical application.	Strongly Agree	Agree	Un-Decided	Dis-agree	Strongly Disagree
It is not easy to score well in mathematics.	Strongly Agree	Agree	Un-Decided	Dis-agree	Strongly Disagree
Mathematics is meant for only intelligent students.	Strongly Agree	Agree	Un-Decided	Dis-agree	Strongly Disagree
Mathematics teacher is not good.	Strongly Agree	Agree	Un-Decided	Dis-agree	Strongly Disagree
There are less job opportunities for mathematics, compared to science subjects.	Strongly Agree	Agree	Un-Decided	Dis-agree	Strongly Disagree
Women are down-to-earth practical while mathematics is abstract	Strongly Agree	Agree	Un-Decided	Dis-agree	Strongly Disagree

C. There are not many top level women Mathematicians. Do you agree with this statement ?

Yes ☐ No ☐

If yes, please indicate the reason for that by ticking the appropriate option.

Women are down-to-earth practical while mathematics is abstract	Strongly Agree	Agree	Un-Decided	Dis-agree	Strongly Disagree
Parents do not agree girls to take up higher mathematics.	Strongly Agree	Agree	Un-Decided	Dis-agree	Strongly Disagree
Genetic factors of female do not promote creative work in mathematics.	Strongly Agree	Agree	Un-Decided	Dis-agree	Strongly Disagree
Social factors do not favour the girls to go for higher studies in mathematics.	Strongly Agree	Agree	Un-Decided	Dis-agree	Strongly Disagree
Girls self-esteem decreases during adolescence more than that of	Strongly Agree	Agree	Un-Decided	Dis-agree	Strongly Disagree

Geometry is very useful in daily life situations like construction of buildings, designing of patterns in textile industry etc.	Strongly Agree	Agree	Un-Decided	Dis-agree	Strongly Disagree
Mathematics is a language of science.	Strongly Agree	Agree	Un-Decided	Dis-agree	Strongly Disagree
Mathematics is very useful in business.	Strongly Agree	Agree	Un-Decided	Dis-agree	Strongly Disagree
Hallmark of Mathematics is precision.	Strongly Agree	Agree	Un-Decided	Dis-agree	Strongly Disagree
One of the vastest areas of the world of contemplative beauty is mathematics and this is sufficient reason for the study of mathematics.	Strongly Agree	Agree	Un-Decided	Dis-agree	Strongly Disagree

II. People do not like Mathematics because

Mathematics is a difficult subject.	Strongly Agree	Agree	Un-Decided	Dis-agree	Strongly Disagree
Mathematics involves some kind of logical thinking.	Strongly Agree	Agree	Un-Decided	Dis-agree	Strongly Disagree
Mathematics is a language of complete abstraction.	Strongly Agree	Agree	Un-Decided	Dis-agree	Strongly Disagree
Mathematics is a very boring subject.	Strongly Agree	Agree	Un-Decided	Dis-agree	Strongly Disagree
Mathematics is full of symbols.	Strongly Agree	Agree	Un-Decided	Dis-agree	Strongly Disagree
Mathematics is made of unrelated topics	Strongly Agree	Agree	Un-Decided	Dis-agree	Strongly Disagree
New discoveries are seldom are made in mathematics.	Strongly Agree	Agree	Un-Decided	Dis-agree	Strongly Disagree
It is difficult to concentrate on mathematics.	Strongly Agree	Agree	Un-Decided	Dis-agree	Strongly Disagree
Mathematics formulae can be easily forgotten.	Strongly Agree	Agree	Un-Decided	Dis-agree	Strongly Disagree
Parents do not encourage to take mathematics.	Strongly Agree	Agree	Un-Decided	Dis-agree	Strongly Disagree
Teachers do not teach mathematics well.	Strongly Agree	Agree	Un-Decided	Dis-agree	Strongly Disagree

boys.					
Vocational interests of women are different.	Strongly Agree	Agree	Un- Decided	Dis- agree	Strongly Disagree
Brain system of girls is different from that of boys.	Strongly Agree	Agree	Un- Decided	Dis- agree	Strongly Disagree
Girls prefer careers that involve living things (like Biology Medicine).	Strongly Agree	Agree	Un- Decided	Dis- agree	Strongly Disagree

D. Would you like to give your own comments on Sex Difference and Mathematical ability ?

Yes ☐ No ☐

If yes, please give your comments :

•

APPENDIX – III

ADDITIONAL REFERENCES

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